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Personal Care Product Use during Puberty and Incident Breast Cancer among Black, Hispanic/Latina, and White Women in a Prospective US-Wide Cohort

Mandy Goldberg,[1] Che-Jung Chang,[1] Kemi Ogunsina,[1] Katie M. O'Brien,[1] Kyla W. Taylor,[2] Alexandra J. White,[1] and Dale P. Sandler[1]

[1]Epidemiology Branch, National Institute of Environmental Health Sciences (NIEHS), National Institutes of Health (NIH), Department of Health and Human Services (DHHS), Research Triangle Park, North Carolina, USA
[2]Integrative Health Assessments Branch, Division of Translational Toxicology, NIEHS, NIH, DHHS, Research Triangle Park, North Carolina, USA

Background: Some personal care products (PCPs) contain endocrine-disrupting chemicals that may affect breast cancer (BC) risk. Patterns of use vary by race and ethnicity. Use often starts in adolescence, when rapidly developing breast tissue may be more susceptible to environmental carcinogens. Few studies have examined associations of BC with PCP use during this susceptible window.

Objectives: We characterized race and ethnicity-specific patterns of PCP use at 10–13 years of age and estimated associations of use with incident BC.

Methods: At enrollment (2003–2009), Sister Study participants ($n = 4{,}049$ Black, 2,104 Latina, and 39,312 White women) 35–74 years of age reported use of 37 "everyday" PCPs during the ages of 10–13 y (did not use, sometimes, or frequently used). We conducted race and ethnicity-specific latent class analyses to separately identify groups of women with similar patterns of beauty, hair, and skincare/hygiene product use. We estimated hazard ratios (HRs) and 95% confidence intervals (CIs) for associations of identified PCP classes and single products with incident BC using Cox proportional hazards regression.

Results: During a mean follow-up time of 10.8 y, 280 Black, 128 Latina, and 3,137 White women were diagnosed with BC. Classes of adolescent PCP use were not clearly associated with BC diagnosis among Black, Latina, or White women. HRs were elevated but imprecise for frequent nail product and perfume use in Black women (HR = 1.34; 95% CI: 0.85, 2.12) and greater hair product use in Black (HR = 1.28; 95% CI: 0.91, 1.80) and Latina (HR = 1.42; 95% CI: 0.81, 2.48) women compared with lighter use. In single-product models, we observed higher BC incidence associated with frequent use of lipstick, nail products, pomade, perfume, makeup remover, and acne/blemish products in at least one group.

Discussion: This work provides some support for the hypothesis that PCP use during puberty is associated with BC risk. More research is needed to confirm these novel findings. https://doi.org/10.1289/EHP13882

Introduction

Many personal care products (PCPs) contain endocrine-disrupting chemicals (EDCs), including phthalates, parabens, and phenols,[1–4] that may affect breast cancer (BC) risk.[5–7] Although many EDCs used in PCPs are nonpersistent,[8] women can be chronically exposed through regular use. Laboratory studies report that EDCs in PCPs are present in breast tissue,[9] can alter hormone signaling and disrupt mammary gland development in rodents,[5,10] and stimulate proliferation, migration, and invasive activity in human BC cell lines.[5,9] However, epidemiological evidence is inconclusive, with conflicting findings reported across studies that have examined biomarkers of chemicals found in PCPs,[11–17] use of multiple PCPs,[18–20] or use of individual products[21] in relation to BC risk.

The breast is more vulnerable to environmental exposures during periods of rapid development, including during puberty.[22,23] Few prior epidemiological studies have measured PCP-related exposures during this window of BC susceptibility.[5] Puberty may be a particularly relevant period for EDC exposure through PCPs because product use is common in adolescence.[24,25] Previous studies have linked adolescent use of hair straighteners or relaxers to increased BC risk[26–28] but have not examined the contributions of commonly used "everyday" PCPs during puberty, including makeup, hair, skincare, and hygiene products, individually or in combination, to BC incidence.

Studies have demonstrated clear differences in PCP use patterns in women by race and ethnicity.[29–31] More frequent use of certain hair (e.g., relaxers and straighteners), skin (e.g., skin lighteners), and intimate care products (e.g., talcum powder, douche) by women of color have been attributed to structural racism, discrimination, racialized beauty norms, and targeted marketing campaigns under the environmental injustice of beauty conceptual framework.[32,33] Products marketed to Black women have been found to have different chemical composition and contain higher concentrations of EDCs than those marketed to White women.[34] These differences likely contribute to greater body burdens of PCP-related chemicals observed in Black and Hispanic/Latina women compared with non-Hispanic White women in the United States.[35,36] For some chemicals commonly found in PCPs, including monoethyl phthalate and methyl and propyl paraben, disparities in biomarker concentrations between non-Hispanic Black and White women were greater in childhood (<12 years of age) and adolescence (12–19 years of age) than in adulthood,[35] which may reflect the young age at initiation of PCP use by Black girls.[36] Thus, racial and ethnic differences in PCP use is a potentially modifiable factor that may contribute to BC disparities.[37–39]

We examined associations of use of a comprehensive list of everyday PCPs during the ages of 10–13 y, coinciding with the pubertal window of susceptibility, with BC incidence separately among Black or African American, non-Black Hispanic/Latina, and non-Hispanic/Latina White women (hereafter, Black, Latina, and White women, respectively) in the Sister Study, a prospective US-wide cohort. To our knowledge, this is the first epidemiological study to investigate use of these everyday PCPs during puberty in relation to BC risk; we and others have previously

Address correspondence to Dale P. Sandler, Epidemiology Branch, National Institute of Environmental Health Sciences, 111 T.W. Alexander Dr., Research Triangle Park, NC 27709 USA. Email: sandler@niehs.nih.gov

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considered only adult use of these products.[18–21] For our primary analyses, we identified groups of women with similar patterns of beauty, hair, and skincare/hygiene product use through race- and ethnicity-specific latent class analyses and examined the associations of product use classes with incident BC. We hypothesized that classes representing greater product use (e.g., more frequent use of a larger number of product types) during puberty would be associated with increased BC incidence and that associations may vary by estrogen-related factors, including menopausal status, estrogen receptor (ER) status of the tumor, and age at onset of pubertal breast development (thelarche). Multiple PCPs are frequently used together, and the latent class approach captures real-life use patterns, minimizes confounding by use of correlated products, and accounts for the greater EDC burden associated with use of more products.[8,24,40] We also conducted single-product analyses of incident BC to complement our latent class analyses and ascertain individual products that may warrant additional research.

Methods

Study Sample

The Sister Study is a prospective cohort of 50,884 women enrolled between 2003 and 2009 (for more details, see Sandler et al.[41]). Women were eligible to join if they lived in a US state or Puerto Rico, were between 35 and 74 years of age, and had a sister with a BC diagnosis but did not have a personal history of BC themselves.

Women completed a computer-assisted telephone interview and self-administered questionnaires at enrollment to assess demographics, reproductive and medical history, and lifestyle factors. A PCP use questionnaire was self-administered at enrollment. Women are followed prospectively with annual updates and comprehensive follow-up questionnaires administered every 3 y. Approximately 85% of participants completed the most recent study activity. This analysis used Sister Study Data Release 9.1, including follow-up data up to 30 September 2019. The institutional review board of the National Institutes of Health approved the study. All participants provided written, informed consent.

Because we stratified by race and ethnicity, we did not include participants with unknown race/ethnicity ($n=15$) or who did not self-identify as Black, Latina, or White ($n=1,334$) owing to the small numbers of women who identified as having other racial and ethnic backgrounds (Figure S1), as further described below. Among Black ($n=4,600$), Latina ($n=2,377$), and White ($n=42,558$) participants, we excluded women who withdrew their data ($n=3$), did not complete the PCP questionnaire ($n=902$), or completed an earlier version of the questionnaire that was not specific to PCP use at 10–13 years of age ($n=2,236$). We also excluded women who were diagnosed with BC prior to, at the same age as, or at unknown timing relative to the completion of all baseline study components ($n=84$), had uncertain BC diagnoses ($n=5$), lacked prospective follow-up data ($n=226$), or were missing data for childhood family income level or maximum education level in the household at 13 years of age, which we included as confounders ($n=614$). The analytic sample included 4,049 Black, 2,104 Latina, and 39,312 White women.

Exposure Assessment: PCP Use during Puberty

At enrollment, women reported how often they used 45 types of PCPs during the ages of 10–13 y. Response options for all products were "did not use," "sometimes," "frequently," and "don't know." We were interested in products that may be applied daily, representing a chronic source of EDC exposure. We included 37 products that we defined as everyday PCPs based on the potential for daily use, including 13 beauty products, 6 hair products, and 18 skincare/hygiene products (Figure 1). We did not include 7 hair products that are used periodically (permanent hair dye, semipermanent hair dye, hair color rinses, bleach, frost or highlights, straighteners/relaxers, and permanent body waves). We also did not include douching because the questionnaire did not distinguish between douching with water or chemical douche products. Women also reported their PCP use in the 12 months before enrollment, which we did not include in our analyses because adult use would be a mediator of associations between PCP use during puberty and BC risk.

Assessment of Race and Ethnicity

We asked women to self-identify their race by choosing one or more of the following: American Indian or Alaska Native, Asian, Black or African American, Native Hawaiian or other Pacific Islander, or White. Women were also asked if they considered themselves to be Hispanic or Latina. We categorized all women who identified as Black or African American as Black, including women who identified as Black and one or more other races or Black and Latina, under the assumption that multiracial or multiethnic Black women may experience some of the same sociocultural influences, such as structural racism, discrimination, and targeted marketing, that affect PCP use. We categorized women who reported that they were Hispanic or Latina and did not identify as Black or African American as Latina. Women who identified as White and did not consider themselves as Hispanic or Latina were categorized as White. Women who identified as non-Hispanic and *a*) Asian/Pacific Islander ($n=341$), *b*) American Indian/Alaskan native ($n=93$), or *c*) with two or more of American Indian/Alaskan native, Asian/Pacific Islander, and White ($n=900$), were excluded because the very low numbers of women in these groups precluded stratified analyses.

Covariate Assessment

Potential confounders were identified *a priori*. We categorized participant birth year in approximate 10-y intervals (1928–1939, 1940–1949, 1950–1959, and 1960–1974) as a proxy for potential changes in product use patterns and the composition of PCPs on the market over time. Participants were asked to characterize their family's income level during the majority of their time growing up using the response options of "well off," "middle income," "low income," or "poor." We categorized the participant's report of the highest level of education in the household when they were 13 years of age as less than high school degree, high school degree or equivalent, some college or technical degree, or 4-y college degree or higher. Participants were asked how old they were when they first noticed their breasts developing, which we used to categorize age at thelarche as <10, 10–13, and >13 y. We considered reports of thelarche at ≥ 21 years of age as implausible and set them to missing ($n=29$).[42] Participants reported if they considered themselves to be lighter, heavier, or the same weight as their peers when they were 10 y old. Childhood PCP use could affect body size and timing of thelarche, which in turn could influence subsequent use of PCPs. Therefore, we did not include age at thelarche or relative childhood weight as covariates in our primary multivariable-adjusted models because these factors could be confounders or mediators of associations between PCP use during the 10- to 13-years-of-age period and incident BC depending on their timing relative to the time of product use queried. We also did not include BC risk factors that postdate the exposure assessment period of 10–13 y (e.g., age at menarche, parity, age at first birth) because these factors are also potential mediators.

Outcome Assessment: Incident BC

Our primary outcome was incident BC [invasive or ductal carcinoma *in situ* (DCIS)]. We confirmed self-reported diagnoses and obtained information on tumor invasiveness and ER status through medical records when available (>80% of cases). We used self-reports when records were unavailable given that agreement between self-reports and medical records has been high in the cohort (positive predictive value for total and ER-positive cancer of >99%).[43]

Statistical Analysis

We examined the distributions of participant characteristics among the analytic samples of Black, Latina, and White participants, as well as those excluded from the analyses. We grouped products by type (beauty, hair, skincare/hygiene) and summed the total number of products ever used within each type for each participant, assuming that participants did not use products for which they were missing response data. We visualized the distribution of frequency of use of each product by race and ethnicity through stacked bar charts. We estimated Spearman's rank correlation coefficients (rho) between product use frequencies (coded as ordinal variables) and birth cohort (ordinal, increasing with calendar time), childhood socioeconomic indicators [ordinal from lower to higher socioeconomic status (SES)], and age at thelarche (in years, continuous) within each racial and ethnic group. We estimated pairwise correlations for use of the 37 included PCPs among Black, Latina, and White women using Spearman's rho.

We used race and ethnicity-specific latent class analysis (LCA) to identify groups of women with similar patterns of use of beauty, hair, and skincare/hygiene products using PROC LCA in SAS (version 9.4; SAS Institute, Inc.).[44] For each LCA, we did not include products that were used by <2% of participants (see Table S1 for included products). We dichotomized products if <2% of women reported one of the use categories. Missing data on frequency of use ranged from ~0.5% to 7% per product (Table S2). We included participants with missing individual product data in the LCAs under the assumption that data were missing at random. We excluded the small number of participants missing data on all included products from the product type group LCA and subsequent models of BC incidence (see Table S1). We estimated up to five LCA models for each product type group, with two to six latent classes, and compared model fit using Akaike's information criterion and the Bayesian information criterion.[44,45] We also considered entropy and the interpretability of the classes in selecting the final model and required a minimum class membership probability of at least 5% to allow for sufficient BC cases in each class. Participants were assigned to the class with the highest posterior probability of membership.[46] We labeled classes based on the item response probabilities of the included products and examined the median number of products used by participants in each latent class.

We used Cox proportional hazards regression with age as the timescale to estimate hazard ratios (HRs) and 95% confidence intervals (CIs) for the associations of race and ethnicity-specific latent classes of beauty, hair, and skincare/hygiene product use with incident BC. Women accrued person-time from age at enrollment until age at diagnosis, with censoring at end of study follow-up (30 September 2019), loss to follow-up, or death. We tested for violations of the proportional hazards assumption using Wald tests of exposure-by-time interaction terms. Any violations of the assumption are indicated in table footnotes. We examined models adjusted only for age as the timescale and multivariable-adjusted models, with the latter including terms for birth cohort, childhood family income, and maximum household education level at 13 years of age. In sensitivity analyses, we additionally adjusted for age at thelarche and relative childhood weight. For each analysis, we used the latent class representing the lowest product use, based on the item response probabilities of the included products and the median number of products used in each class, as the reference.

We examined differences in associations between classes of PCP use and incident BC by BC characteristics. We considered differences by time-varying menopausal status and tested for statistical heterogeneity using a Wald test of the product use–menopause interaction terms. We used fully adjusted joint Cox models stratified by type to estimate associations and test for statistical heterogeneity by ER status and invasiveness.[47] We included invasive and DCIS cases in models of ER status and censored women with the alternative subtype or missing subtype information at age at diagnosis. For models of invasive and DCIS disease, women with the alternate type or missing invasiveness information were censored at age at diagnosis. We estimated associations for strata that included at least 5 cases in each latent class.

We examined timing of thelarche as a potential modifier under the hypothesis that the effect of exogenous estrogens may differ depending on endogenous estrogen concentrations and breast maturation. We stratified models of classes of PCP use in White women by age at thelarche and tested for statistical heterogeneity using a Wald test of the product use–age at thelarche interaction terms. We did not stratify by age at thelarche in Black or Latina women because there were <5 cases in some classes.

We estimated multivariable-adjusted associations of use of individual products with incident BC in race and ethnicity-stratified Cox models. For these single-product models, we combined "frequently" and "sometimes" use categories into an "any-use" category if there were <5 cases in the frequently used group. We did not estimate associations for products with <5 any-use cases. "Nonusers" were used as the referent group if there were at least 10 cases in this category. Because single-product models may be confounded by use of other correlated products, we conducted additional analyses in which we adjusted for the total number of products used within the product type group (e.g., we adjusted for the number of beauty products ever used in the 10- to 13-years-of-age period in analyses of individual beauty products). We excluded participants with missing data on the product of interest from single-product models.

To rule out an influence of adolescent straightener/relaxer use, previously linked with premenopausal BC in this cohort,[26] we conducted sensitivity analyses of associations with everyday hair product classes restricted to women who did not use straighteners/relaxers during the 10- to 13-years-of-age period. Because women may use pomade prior to applying these products,[48] we examined correlations of straightener/relaxer and pomade use and restricted pomade models to nonstraightener/relaxer users.

We conducted sensitivity analyses for the associations of latent classes and single products with incident BC among Black participants excluding bi- and multiracial Black women and Black Latinas because types of products used may vary for women who identify as bi- or multiracial or multiethnic[29,31] and there may be differences in the brands used and associated chemical constituents within the same broad types of products.

We used robust variance estimates to account for within-family clustering. We conducted analyses using SAS (version 9.4; SAS Institute, Inc.) and created figures in R (version 4.2.2; R Development Core Team).

Results

Study Population Characteristics

Distributions of demographic characteristics were similar between the analytic samples of Black, Latina, and White participants and those that were excluded from the analyses (Table S3). During a

Table 1. Participant characteristics among eligible Black or African American, non-Black Hispanic/Latina, and non-Hispanic White women in the Sister Study cohort ($N = 45{,}465$).

Characteristic	Black or African American	Non-Black Hispanic/Latina	Non-Hispanic White
Participants (*n*)	4,049	2,104	39,312
Cases (*n*)	280	128	3,137
Follow-up time [y (mean ± SD)]	9.9 ± 2.8	9.9 ± 2.9	11.0 ± 2.8
Age at baseline [y (mean ± SD)]	53.6 ± 8.3	53.2 ± 9.0	56.1 ± 8.9
Birth cohort [*n* (%)]			
1928–1939	191 (5)	120 (6)	4,982 (13)
1940–1949	1,065 (26)	529 (25)	13,333 (34)
1950–1959	1,709 (42)	820 (39)	14,451 (37)
1960–1974	1,084 (27)	635 (30)	6,546 (17)
Family income level growing up [*n* (%)]			
Well off	118 (3)	108 (5)	2,711 (7)
Middle income	1,683 (42)	847 (40)	24,789 (63)
Low income	1,488 (37)	702 (33)	9,553 (24)
Poor	760 (19)	447 (21)	2,259 (6)
Highest level of education in household at 13 years of age [*n* (%)]			
Less than high school degree	1,513 (37)	1,196 (57)	5,549 (14)
High school degree or equivalent	1,437 (35)	394 (19)	14,460 (37)
Some college or technical degree	637 (16)	215 (10)	7,714 (20)
4-y college degree or higher	462 (11)	299 (14)	11,589 (29)
Age at thelarche [y; *n* (%)]			
<10	266 (7)	123 (6)	1,193 (3)
10–13	2,910 (73)	1,601 (77)	31,108 (80)
>13	810 (20)	346 (17)	6,572 (17)
Missing	63	34	439
Weight relative to peers at 10 years of age [*n* (%)]			
Lighter	1,696 (42)	869 (42)	13,189 (34)
Same weight	1,705 (42)	978 (47)	18,597 (47)
Heavier	626 (16)	245 (12)	7,430 (19)
Missing	22	12	96
Number of products ever used from 10 to 13 years of age [median (25th, 75th percentile)]			
Personal care products	13 (9, 16)	9 (5, 15)	10 (6, 15)
Beauty products	3 (1, 4)	3 (1, 5)	3 (1, 5)
Hair products	3 (2, 4)	2 (1, 3)	2 (1, 3)
Skincare/hygiene products	7 (5, 9)	4 (2, 7)	5 (2, 7)

Note: Column percentages are displayed. Missing data are not included in calculation of percentages. Participants with missing data on family income level growing up and highest level of education in household at 13 years of age were excluded (see Figure S1). SD, standard deviation.

mean follow-up of 10.8 y, 280 Black, 128 Latina, and 3,137 White women were diagnosed with BC (Table 1). Early life demographic characteristics were similar among Black and Latina participants, although the proportion of participants who reported that the highest educational level completed by an adult in their household when they were 13 years of age was less than a high school degree was higher among Latinas. Compared with Black or Latina women, White women were older at baseline, more likely to grow up in a well-off or middle-income household and a household with educational attainment of a 4-y college degree or higher, and less likely to experience thelarche before 10 years of age. The median number of products used during the 10- to 13-years-of-age period was 13 among Black, 9 among Latina, and 10 among White women. The median number of beauty products used in adolescence was 3 in all groups. The median number of hair products used in adolescence was 3 among Black women and 2 among Latina and White women, whereas the median number of skincare/hygiene products used was 7 among Black women, 4 among Latinas, and 5 among White women.

PCP Use during the 10- to 13-Years-of-Age Period by Race and Ethnicity

Perfume, nail polish and polish remover, and lip moisturizers were the most commonly used beauty products during the 10- to 13-years-of-age period, with the highest prevalence of nail polish use reported by Black women and the highest prevalence of perfume use reported by Latina women (Figure 1). Except for lipstick, <20% of Latina and White women and 10% of Black women reported any adolescent use of each makeup product. Almost all Black women (94%) used pomade or hair grease and 27% used hair food in adolescence, whereas these products were used by a small proportion of Latina women and few White women. Hair spray or gel were used by a higher proportion of Latina (36% and 16%, respectively) and White (40% and 16%) participants than Black participants (17% and 11%) during the 10- to 13-years-of-age period. Compared with Latina and White women, Black women were more frequent adolescent users of most skincare/hygiene products, particularly lotions or creams, oils, and petroleum jelly. Talcum powder was also used more frequently by Black women during adolescence.

Correlations between product use frequencies during the 10- to 13-years-of-age period and covariates of interest were generally weak in magnitude but exhibited similar patterns across racial and ethnic groups (Figure S2, Excel Table S1). Use of most products during the 10- to 13-years-of-age period was inversely correlated with age at thelarche, with the strongest correlations observed for deodorant, perfume, and makeup products. Product use increased with birth cohort, except for lipstick and talc products, which were used less frequently by women born in later years. Product use tended to increase with family income and household education.

Patterns of correlations between product use frequencies during the 10- to 13-years-of-age period were similar among Black, Latina, and White women (Figures S3–S5, Excel Tables S2–S4). Use of products within a category (beauty, hair, and skincare/hygiene) were positively correlated. Correlations of products across categories were smaller in magnitude. Spearman's rho ranged from 0.4 to 0.7 for most makeup products, but the correlation was 0.9 for nail polish and nail polish remover. Hair spray and hair gel use were positively correlated in all groups (rho = 0.4), whereas pomade/hair grease and hair food use were correlated in Latina women (rho = 0.4). Use of talc products on different areas of the body was positively correlated (rho = 0.3–0.5), as was lotion use (rho = 0.6–0.7 for body and hand lotion).

Latent Classes of PCP Use during the 10- to 13-Years-of-Age Period and Incident BC

Among Black women, we selected the four-class model for beauty products, three-class model for hair products, and four-class model for skincare/hygiene products based on model fit (Table S1) and interpretability (Figure S6, Excel Table S5). Latent classes of product use were not clearly associated with BC risk (Table 2). Compared with the class characterized by some perfume and lip moisturizer use, the estimated HR for the frequent nail product and perfume use class was 1.34 (95% CI: 0.85, 2.12). HRs were positive in direction but CIs were wide for classes representing frequent use of shampoo, conditioner, and pomade and some use of hair spray, hair gel, and hair food (HR = 1.28; 95% CI: 0.91, 1.80) and frequent shampoo, conditioner, and pomade use (HR = 1.24; 95% CI: 0.94, 1.63) compared with frequent pomade and some shampoo use only, and for frequent lotions, some moisturizers, and little talc use (HR = 1.22; 95% CI: 0.85, 1.73) compared with some use of lotions and petroleum jelly.

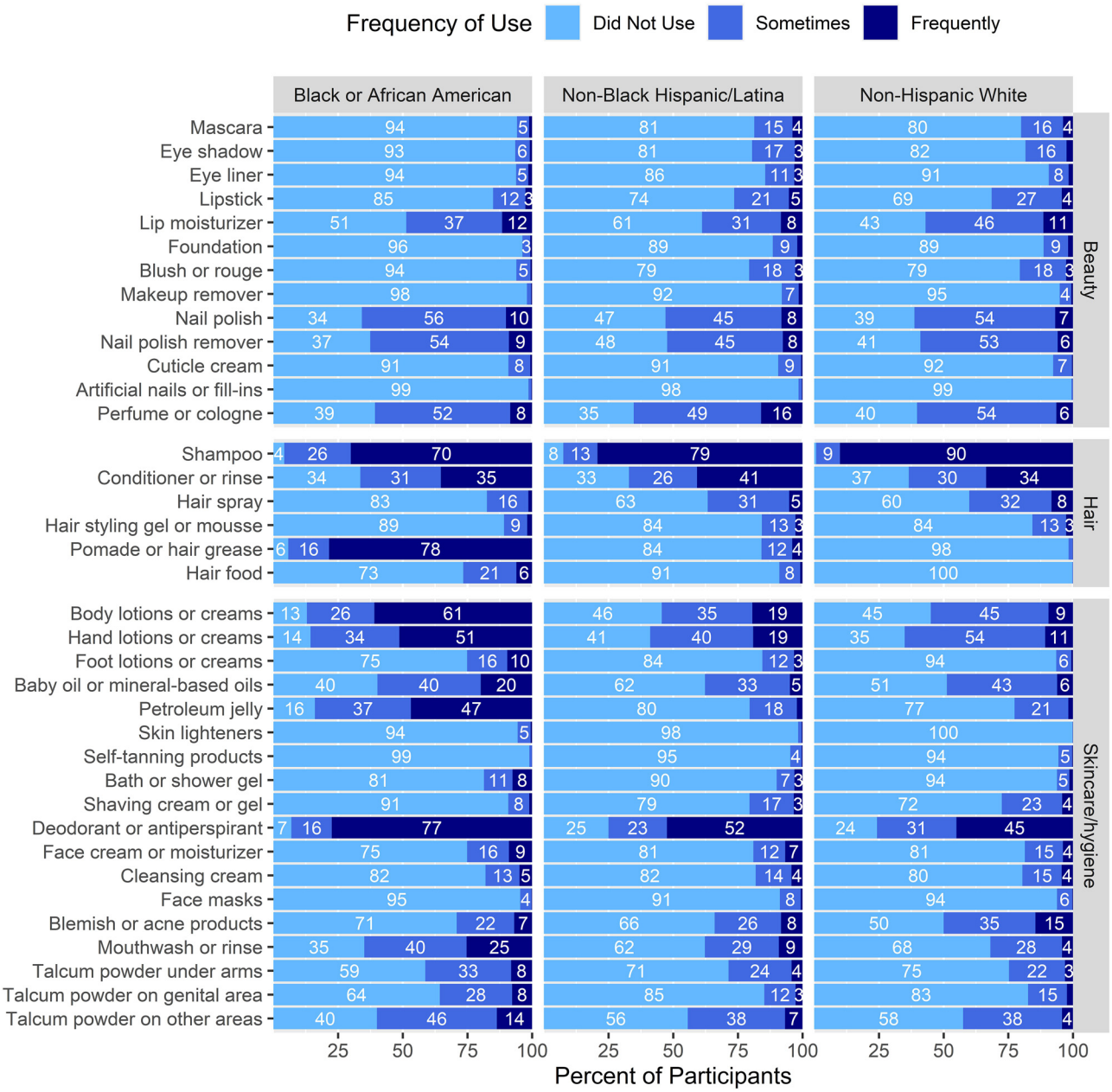

Figure 1. Frequency of self-reported personal care product use during the ages of 10–13 y by race and ethnicity in the Sister Study. Darker shading indicates more frequent product use. Numbers indicate the percentage of participants in each frequency category. Categories without a number include <3% of participants.

Among Latina women, our final LCA models included four classes for beauty products, three classes for hair products, and four classes for skincare/hygiene products (Figure S7, Excel Table S6). The HR for frequent use of shampoo and conditioner and some use of hair spray, hair food, hair gel, and pomade relative to some shampoo use was 1.42 (95% CI: 0.81, 2.48) and the HR for frequent shampoo and conditioner use was 1.62 (95% CI: 0.96, 2.74) (Table 2). There were no clear patterns for associations with classes of beauty or skincare/hygiene product use. The HR was inverse for some use of some moisturizers and talc products (HR = 0.57; 95% CI: 0.32, 1.02) compared with little use of any skincare/hygiene products.

Among White women, we identified three classes for beauty products, four classes for hair products, and four classes for skincare/hygiene products based on the final LCA model (Figure S8, Excel Table S7). HRs for BC incidence were all close to 1 for beauty, hair, or skincare/hygiene product use classes (Table 2). Results were similar in models additionally adjusted for age at thelarche and relative childhood weight among Black, Latina, and White women (Table S4).

There was no clear heterogeneity by menopausal status in Black and White women (Table S5). We did not observe strong differences by ER status (Table S6). Although associations for hair product use classes were farther from the null for ER-negative [HR = 1.49 (95% CI: 0.63, 3.48) for frequent shampoo, conditioner, and pomade and some hair spray, hair gel, and pomade use and HR = 1.58 (95% CI: 0.82, 3.03) for frequent shampoo, conditioner, and pomade use, respectively] than ER-positive cancer [HR = 1.22 (95% CI: 0.78, 1.91) and HR = 1.22 (95% CI: 0.84, 1.77), respectively] in Black women, estimates were based

Table 2. Associations between latent classes of self-reported personal care product use during the 10- to 13-years-of-age period and incident breast cancer among Black or African American, non-Black Hispanic/Latina, and non-Hispanic White women in the Sister Study.

Race and ethnicity-specific latent class	Number of products used (median)[a]	Person-years	*n* cases	Age-adjusted HR (95% CI)[b]	Multivariable-adjusted HR (95% CI)[c]
Black or African American women ($n = 4{,}049$)					
Latent classes of beauty product use from 10 to 13 years of age					
Any makeup, nail product, and perfume use	7	3,610	24	1.00 (0.64, 1.55)	1.03 (0.66, 1.60)
Frequent nail product and perfume use	4	2,568	23	1.33 (0.84, 2.11)	1.34 (0.85, 2.12)
Some nail product and perfume use	3	20,104	127	0.89 (0.68, 1.15)	0.89 (0.69, 1.15)
Some use of perfume and lip moisturizer	1	13,931	106	1 (Ref)	1 (Ref)
Latent classes of hair product use from 10 to 13 years of age					
Frequent shampoo, conditioner, and pomade and some hair spray, hair gel, and hair food	5	7,317	52	1.25 (0.89, 1.74)	1.28 (0.91, 1.80)
Frequent shampoo, conditioner, and pomade	3	15,197	106	1.22 (0.93, 1.59)	1.24 (0.94, 1.63)
Frequent pomade and some shampoo	2	17,565	122	1 (Ref)	1 (Ref)
Latent classes of skincare/hygiene product use from 10 to 13 years of age[d]					
Frequent moisturizers, including lotions, oil, and petroleum jelly, and some cleanser, hygiene products, and talc use	10	10,761	69	1.02 (0.71, 1.47)	1.05 (0.73, 1.52)
Frequent lotions, some use of other moisturizers, and little talc use	7	10,607	78	1.19 (0.84, 1.69)	1.22 (0.85, 1.73)
Some moisturizers, including lotions, oil, and petroleum jelly, and talc use	7	11,444	81	1.02 (0.72, 1.44)	1.02 (0.72, 1.44)
Some use of lotions and petroleum jelly	3	7,401	52	1 (Ref)	1 (Ref)
Non-Black Hispanic/Latina women ($n = 2{,}104$)					
Latent classes of beauty product use from 10 to 13 years of age					
Frequent nail product and perfume and any makeup use	9	1,240	8	1.15 (0.54, 2.42)	1.17 (0.55, 2.50)
Some nail product and perfume and any makeup use	7	3,293	16	0.85 (0.48, 1.49)	0.87 (0.49, 1.53)
Some nail product and perfume and little makeup use	3	7,203	52	1.25 (0.85, 1.83)	1.27 (0.86, 1.88)
Some use of perfume and lip moisturizer	1	9,036	52	1 (Ref)	1 (Ref)
Latent classes of hair product use from 10 to 13 years of age					
Frequent shampoo and conditioner and some hair spray, hair food, hair gel, and pomade	3	7,495	45	1.39 (0.81, 2.41)	1.42 (0.81, 2.48)
Frequent shampoo and conditioner	2	8,973	64	1.62 (0.96, 2.73)	1.62 (0.96, 2.74)
Some shampoo	1	4,234	19	1 (Ref)	1 (Ref)
Latent classes of skincare/hygiene product use from 10 to 13 years of age					
Frequent lotions and some oil, petroleum jelly, cleanser, hygiene products, and talc use	10	4,067	20	0.73 (0.43, 1.24)	0.72 (0.41, 1.26)
Frequent lotions, some use of other moisturizers, and little talc use	5	6,344	48	1.10 (0.73, 1.67)	1.11 (0.73, 1.68)
Some moisturizers, including lotions, oil, and petroleum jelly, and talc use	5	4,013	16	0.57 (0.32, 1.01)	0.57 (0.32, 1.02)
Little use of any products	1	6,322	44	1 (Ref)	1 (Ref)
Non-Hispanic White women ($n = 39{,}312$)					
Latent classes of beauty product use from 10 to 13 years of age					
Any makeup, nail product, and perfume use	8	90,492	603	1.01 (0.91, 1.12)	1.01 (0.91, 1.12)
Nail product and perfume and little makeup use	4	180,610	1,325	1.00 (0.93, 1.08)	1.00 (0.92, 1.08)
Some use of perfume and lip moisturizer	1	160,614	1,209	1 (Ref)	1 (Ref)
Latent classes of hair product use from 10 to 13 years of age[d]					
Frequent shampoo, conditioner, and hair spray and some hair gel	4	25,479	179	1.06 (0.90, 1.24)	1.06 (0.90, 1.24)
Frequent shampoo and conditioner and some hair spray use	3	113,949	814	1.04 (0.96, 1.13)	1.04 (0.95, 1.13)
Frequent shampoo and conditioner use	2	68,891	443	1.00 (0.89, 1.11)	1.00 (0.89, 1.12)
Frequent shampoo and some conditioner	1	222,820	1,697	1 (Ref)	1 (Ref)
Latent classes of skincare/hygiene product use from 10 to 13 years of age					
Frequent moisturizers, including lotions and oil, some petroleum jelly, cleanser, hygiene products, and talc use	10	67,010	446	0.96 (0.85, 1.07)	0.95 (0.85, 1.07)
Some moisturizers, including lotions and oil, and talc use	7	81,612	581	0.93 (0.84, 1.03)	0.93 (0.84, 1.03)
Some moisturizers, including lotions and oil, little talc use	5	146,826	1,050	0.98 (0.90, 1.07)	0.98 (0.90, 1.07)
Little use of any products	2	136,291	1,060	1 (Ref)	1 (Ref)

Note: CI, confidence interval; HR, hazard ratio; Ref, reference.
[a]Sum of the number of products used within each product type group (beauty, hair, skincare/hygiene, respectively).
[b]Adjusted for age as the timescale.
[c]Adjusted for birth cohort in ~10-y intervals, family income level growing up (well off, middle income, low income, poor), and maximum household education level at 13 years of age (less than high school, high school graduate or equivalent, some college or technical school, 4-y degree or higher) in addition to age as the timescale.
[d]Proportional hazards assumption violated for exposure in multivariable model ($p < 0.05$).

on small numbers of ER-negative cancers and were not statistically different from each other [p for heterogeneity (p_{het}) = 0.80]. We observed some differences in associations of classes of hair product use and BC incidence by tumor invasiveness (Table S7). Frequent use of shampoo, conditioner, and pomade and some use of hair spray, hair gel, and pomade was associated with 52% higher incidence of invasive tumors (95% CI: 1.04, 2.23) in Black women, whereas the estimated HR was inverse for DCIS (HR = 0.68; 95% CI: 0.32, 1.46; $p_{het} = 0.12$). We observed a similar pattern for frequent use of shampoo, conditioner, and hair

spray and some use of hair gel in White women [HR = 1.17 (95% CI: 0.98, 1.39) for invasive and HR = 0.72 (95% CI: 0.49, 1.06) for DCIS; $p_{het} = 0.01$]. The HR for frequent nail product and perfume use among Black women was farther from the null in analyses of invasive disease (HR = 1.53; 95% CI: 0.90, 2.59), as was the HR for frequent nail product and perfume and any makeup use among Latinas (HR = 1.56; 95% CI: 0.72, 3.35). Among White women, we did not observe statistical differences by timing of thelarche (Table S8), although we observed a suggestively higher incidence associated with the frequent use of shampoo, conditioner, and hair spray and some use of hair gel class (HR = 1.38; 95% CI: 0.91, 2.09) and the frequent shampoo and conditioner and some hair spray use class (HR = 1.24; 95% CI: 0.98, 1.56) among women with late thelarche.

Use of Individual Products during the 10- to 13-Years-of-Age Period and Incident BC

Frequent use of lipstick during the 10- to 13-years-of-age period was associated with higher BC incidence among Black (HR = 1.91; 95% CI: 1.09, 3.32) and White (HR = 1.22; 95% CI: 1.04, 1.44) women compared with nonuse, whereas the HR was 1.26 among Latinas (95% CI: 0.61, 2.60) (Table 3). Frequent use of makeup remover was associated with a 60% higher incidence in White women (95% CI: 1.10, 2.32), whereas the HR for any use was 1.41 among Latinas (95% CI: 0.78, 2.55). Among Black women, frequent use of cuticle cream was associated with higher BC risk (HR = 2.87; 95% CI: 1.25, 6.57), whereas the HR was 1.23 (95% CI: 0.81, 1.86) for frequent use of nail polish and 1.30 (95% CI: 0.85, 1.99) for nail polish remover. In Latinas, any use of artificial nails or fill-ins was associated with BC incidence (HR = 2.87; 95% CI: 1.19, 6.91). Among White women, we observed an association with frequent use of perfume (HR = 1.17; 95% CI: 1.00, 1.35), but not nail products. Frequent use of pomade was positively associated with BC in Latinas (HR = 2.43; 95% CI: 1.27, 4.67) (Table 4). Among Black women, the HR was 1.55 (95% CI: 0.82, 2.96) for frequent pomade use and 1.78 (95% CI: 0.89, 3.53) for some use. Among White women, the HR for frequent pomade use was 1.69 (95% CI: 0.76, 3.75). HRs ranged from 1.13 to 1.26 for body lotions and creams in Black and Latina women and petroleum jelly in Black women, although CIs were wide. Frequent hand lotion use was inversely associated with BC in White women (HR = 0.85; 95% CI: 0.74, 0.97) (Table 5). Frequent use of blemish/acne products was associated with BC in White women (HR = 1.16; 95% CI: 1.04, 1.29). The inference was similar in models that accounted for coexposure to other correlated products through adjustment for the total number of beauty, hair, or skincare/hygiene products used (Tables S9–S11).

Sensitivity Analyses for Hair Product Models, Excluding Straightener/Relaxer Users

Approximately 75% of Black, 8.5% of Latina, and 3.5% of White women reported straightener/relaxer use during the 10- to 13-years-of-age period. Use of straighteners/relaxers was correlated with pomade use among Black and Latina women (rho = 0.3), but not White women (rho = 0.1). Among Black nonstraightener/relaxer users ($n = 980$), the HR for BC associated with the frequent shampoo, conditioner, and pomade use and some hair spray, hair gel, and hair food use class was farther from the null but imprecise (HR = 1.62; 95% CI: 0.85, 3.10), whereas the HR for frequent use of shampoo, conditioner, and pomade was 1 (95% CI: 0.59, 1.71). HRs of hair product classes with incident BC were slightly attenuated among Latina nonstraightener/relaxer users [$n = 1{,}888$, HR = 1.21 (95% CI: 0.67, 2.20) for frequent shampoo and conditioner and some hair spray, hair food, hair gel, and pomade use and HR = 1.53 (95% CI: 0.90, 2.60) for frequent shampoo and conditioner use]. The HRs for BC associated with pomade use restricted to nonstraightener/relaxer users were stronger in magnitude in Black women [HR = 1.75 (95% CI: 0.72, 4.26) for frequent and HR = 1.91 (95% CI: 0.74, 4.96) for some pomade use vs. did not use] and slightly attenuated in Latina and White women [HR = 1.28 (95% CI: 0.45, 3.68) and HR = 1.41 (95% CI: 0.53, 3.76) for frequent use, respectively] compared with our overall results.

Sensitivity Analyses Excluding Bi- or Multiracial Black Women and Black Latinas

Associations of latent classes of product use with incident BC and results from single-product models were similar in analyses excluding bi- or multiracial Black women and Black Latinas (Table S12). Frequent use of foundation was also associated with BC risk in analyses excluding bi- or multiracial Black women and Black Latinas (HR = 1.85; 95% CI: 1.07, 3.17).

Discussion

In this US-wide prospective cohort, we characterized patterns of PCP use during the 10- to 13-years-of-age period among Black, Latina, and White women through latent class analyses and examined associations of product use classes and individual product use with BC incidence. There were clear differences in product use by race and ethnicity, particularly for hair pomade, body moisturizers, and some hygiene products, which were used much more frequently by Black participants. Classes of PCP use during puberty were not clearly associated with BC incidence. Although CIs were wide, point estimates suggested a possible higher hazard of BC associated with latent classes characterized by greater use of nail and hair products among Black and Latina women, whereas point estimates for all beauty and hair product classes were close to the null among White women. Associations of classes of skincare/hygiene product use with BC incidence varied by race and ethnicity, with no clear trends observed. In single-product models, lipstick, makeup remover, nail products, perfume, pomade, and blemish/acne product use were positively associated with BC incidence in at least one racial and ethnic group, and hand cream was inversely associated with BC in White women only.

Classes characterized by use of makeup products were not associated with risk. However, use of makeup remover, which may serve as a surrogate for greater makeup use, was positively associated with BC incidence in White women. We observed positive associations of lipstick use with BC in Black, White, and possibly Latina women. Lipstick may be reapplied throughout the day and women may be exposed to the chemicals in lipsticks through ingestion in addition to dermal absorption, leading to greater chemical exposure. Lip moisturizers were not associated with BC, suggesting that the types of chemicals or chemical concentrations within lipstick products specifically may be associated with increased risk. Lipsticks have been found to contain EDCs, such as phthalates, parabens, and alkylphenols,[1,4] as well as metals, including lead.[49]

Latent class models suggested that frequent use of nail products may be positively associated with BC among Black and Latina women, with stronger HRs observed when restricted to invasive disease. Single-product models also supported an association with nail products. Nail products have been found to contain plasticizers, including phthalates and organophosphates,[1,50] metals,[51] and other toxic chemicals known or suspected to be carcinogenic,[52] such as formaldehyde, toluene, benzene, and methylene chloride.[50,53–55] In White women, frequent use of perfume, a source

Table 3. Associations between use of self-reported single beauty products during the 10- to 13-years-of-age period and incident breast cancer by race and ethnicity in the Sister Study.

	Black or African American ($n = 4{,}049$)			Non-Black Hispanic/Latina ($n = 2{,}104$)			Non-Hispanic White ($n = 39{,}312$)		
Product	Use	*n* cases	Adjusted HR (95% CI)[a]	Use	*n* cases	Adjusted HR (95% CI)[a]	Use	*n* cases	Adjusted HR (95% CI)[a]
Mascara	Frequently or sometimes	13	0.89 (0.51, 1.55)	Frequently	5	0.96 (0.39, 2.35)	Frequently	109	1.02 (0.84, 1.23)
				Sometimes	16	0.83 (0.48, 1.41)	Sometimes	447	0.95 (0.86, 1.05)
	Did not use	264	1 (Ref)	Did not use	107	1 (Ref)	Did not use	2,550	1 (Ref)
Eye shadow	Frequently or sometimes[b]	17	1.12 (0.68, 1.85)	Frequently or sometimes	20	0.76 (0.46, 1.23)	Frequently	62	0.92 (0.71, 1.18)
							Sometimes	443	0.99 (0.89, 1.10)
	Did not use[b]	260	1 (Ref)	Did not use	108	1 (Ref)	Did not use	2,610	1 (Ref)
Eye liner	Frequently or sometimes	14	0.91 (0.52, 1.57)	Frequently	5	1.31 (0.54, 3.21)	Frequently	55	1.22 (0.94, 1.60)
				Sometimes	15	1.11 (0.64, 1.92)	Sometimes	216	1.01 (0.88, 1.16)
	Did not use	262	1 (Ref)	Did not use	108	1 (Ref)	Did not use	2,833	1 (Ref)
Lipstick	Frequently	13	1.91 (1.09, 3.32)	Frequently	8	1.26 (0.61, 2.60)	Frequently	163	1.22 (1.04, 1.44)
	Sometimes	34	0.99 (0.69, 1.42)	Sometimes	24	0.88 (0.56, 1.38)	Sometimes	886	1.05 (0.97, 1.14)
	Did not use	229	1 (Ref)	Did not use	96	1 (Ref)	Did not use	2,039	1 (Ref)
Lip moisturizer	Frequently	31	1.24 (0.83, 1.86)	Frequently	7	0.71 (0.33, 1.56)	Frequently	305	0.95 (0.83, 1.09)
	Sometimes	96	1.05 (0.80, 1.38)	Sometimes	43	1.18 (0.81, 1.73)	Sometimes	1,302	0.96 (0.88, 1.04)
	Did not use	144	1 (Ref)	Did not use	75	1 (Ref)	Did not use	1,391	1 (Ref)
Foundation	Frequently or sometimes	14	1.45 (0.84, 2.50)	Frequently or sometimes	15	1.08 (0.63, 1.84)	Frequently	47	0.89 (0.67, 1.19)
							Sometimes	293	1.08 (0.96, 1.22)
	Did not use	262	1 (Ref)	Did not use	113	1 (Ref)	Did not use	2,758	1 (Ref)
Blush or rouge	Frequently or sometimes	17	1.10 (0.67, 1.80)	Frequently	6	1.73 (0.73, 4.08)	Frequently	71	1.00 (0.78, 1.27)
				Sometimes	19	0.81 (0.50, 1.33)	Sometimes	526	1.04 (0.95, 1.15)
	Did not use	258	1 (Ref)	Did not use	103	1 (Ref)	Did not use	2,489	1 (Ref)
Makeup remover	Frequently or sometimes	<5[c]	NE[c]	Frequently or sometimes[b]	13	1.41 (0.78, 2.55)	Frequently	28	1.60 (1.10, 2.32)
							Sometimes	125	1.03 (0.86, 1.23)
	Did not use	275	NE[c]	Did not use[b]	113	1 (Ref)	Did not use	2,958	1 (Ref)
Nail polish	Frequently	30	1.23 (0.81, 1.86)	Frequently	11	1.26 (0.65, 2.44)	Frequently	177	0.91 (0.78, 1.07)
	Sometimes	138	0.95 (0.73, 1.23)	Sometimes	60	1.23 (0.84, 1.80)	Sometimes	1,616	0.99 (0.92, 1.06)
	Did not use	96	1 (Ref)	Did not use	51	1 (Ref)	Did not use	1,199	1 (Ref)
Nail polish remover	Frequently	27	1.30 (0.85, 1.99)	Frequently	9	1.09 (0.53, 2.22)	Frequently	142	0.85 (0.72, 1.02)
	Sometimes	135	0.98 (0.76, 1.27)	Sometimes	61	1.23 (0.84, 1.79)	Sometimes	1,569	0.99 (0.91, 1.06)
	Did not use	104	1 (Ref)	Did not use	53	1 (Ref)	Did not use	1,270	1 (Ref)
Cuticle cream	Frequently[b]	5	2.87 (1.25, 6.57)	Frequently or sometimes	9	0.75 (0.38, 1.49)	Frequently	8	0.71 (0.36, 1.42)
	Sometimes[b]	20	0.92 (0.58, 1.47)				Sometimes	225	1.04 (0.91, 1.19)
	Did not use[b]	248	1 (Ref)	Did not use	115	1 (Ref)	Did not use	2,830	1 (Ref)
Artificial nails or fill-ins	Frequently or sometimes	<5[c]	NE[c]	Frequently or sometimes	5	2.87 (1.19, 6.91)	Frequently or sometimes	19	1.09 (0.69, 1.70)
	Did not use	274	NE[c]	Did not use	123	1 (Ref)	Did not use	3,109	1 (Ref)
Perfume or cologne	Frequently	17	0.85 (0.51, 1.42)	Frequently	16	0.97 (0.54, 1.74)	Frequently	203	1.17 (1.00, 1.35)
	Sometimes	147	1.10 (0.86, 1.42)	Sometimes	65	1.21 (0.81, 1.81)	Sometimes	1,626	1.06 (0.98, 1.15)
	Did not use	106	1 (Ref)	Did not use	38	1 (Ref)	Did not use	1,159	1 (Ref)

Note: Participants with missing data on the product of interest are excluded from single-product model. CI, confidence interval; HR, hazard ratio; NE, not estimated; Ref, reference.

[a]Adjusted for birth cohort in ~10-y intervals, family income level growing up (well off, middle income, low income, poor), and maximum household education level at 13 years of age (less than high school, high school graduate or equivalent, some college or technical school, 4-y degree or higher) in addition to age as the timescale.

[b]Proportional hazards assumption violated for product use variable ($p < 0.05$).

[c]We did not estimate associations for products with <5 exposed cases. To protect participant confidentiality, we do not report exact case numbers if <5.

Table 4. Associations between self-reported use of single hair products during the 10- to 13-years-of-age period and incident breast cancer by race and ethnicity in the Sister Study.

	Black or African American ($n = 4{,}049$)			Non-Black Hispanic/Latina ($n = 2{,}104$)			Non-Hispanic White ($n = 39{,}312$)		
Product	Use	*n* cases	Adjusted HR (95% CI)[a]	Use	*n* cases	Adjusted HR (95% CI)[a]	Use	*n* cases	Adjusted HR (95% CI)[a]
Shampoo	Frequently[b]	194	1.44 (0.77, 2.69)	Frequently	104	1 (Ref)	Frequently	2,756	1.07 (0.71, 1.63)
	Sometimes[b]	64	1.13 (0.59, 2.19)	Sometimes	11	0.63 (0.34, 1.19)	Sometimes	300	1.07 (0.70, 1.64)
	Did not use[b]	10	1 (Ref)	Did not use	6	0.64 (0.27, 1.49)	Did not use	23	1 (Ref)
Conditioner or rinse	Frequently	74	1.04 (0.74, 1.47)	Frequently	53	1.36 (0.84, 2.21)	Frequently	920	1.04 (0.94, 1.15)
	Sometimes	93	1.29 (0.96, 1.75)	Sometimes	33	1.27 (0.77, 2.10)	Sometimes	896	1.04 (0.95, 1.15)
	Did not use	93	1 (Ref)	Did not use	33	1 (Ref)	Did not use	1,167	1 (Ref)
Hair spray	Frequently or sometimes	49	1.11 (0.81, 1.51)	Frequently	6	0.91 (0.38, 2.15)	Frequently[b]	260	1.10 (0.97, 1.26)
				Sometimes	38	0.99 (0.66, 1.47)	Sometimes[b]	969	1.05 (0.97, 1.14)
	Did not use	226	1 (Ref)	Did not use	80	1 (Ref)	Did not use[b]	1,784	1 (Ref)
Hair styling gel or mousse	Frequently or sometimes	27	0.99 (0.66, 1.49)	Frequently or sometimes	15	0.76 (0.44, 1.31)	Frequently[b]	79	1.10 (0.87, 1.38)
							Sometimes[b]	371	1.00 (0.90, 1.12)
	Did not use	246	1 (Ref)	Did not use	113	1 (Ref)	Did not use[b]	2,605	1 (Ref)
Pomade or hair grease	Frequently	214	1.55 (0.82, 2.96)	Frequently	11	2.43 (1.27, 4.67)	Frequently	6	1.69 (0.76, 3.75)
	Sometimes	50	1.78 (0.89, 3.53)	Sometimes	11	0.79 (0.42, 1.47)	Sometimes	52	1.02 (0.77, 1.34)
	Did not use	10	1 (Ref)	Did not use	103	1 (Ref)	Did not use	3,056	1 (Ref)
Hair food	Frequently	16	1.19 (0.69, 2.04)	Frequently or sometimes	10	0.92 (0.48, 1.77)	Frequently or sometimes	9	1.18 (0.61, 2.28)
	Sometimes	46	0.93 (0.66, 1.30)						
	Did not use	207	1 (Ref)	Did not use	117	1 (Ref)	Did not use	3,082	1 (Ref)

Note: Participants with missing data on the product of interest are excluded from single-product model. CI, confidence interval; HR, hazard ratio; Ref, reference.
[a]Adjusted for birth cohort in ~10-y intervals, family income level growing up (well off, middle income, low income, poor), and maximum household education level at 13 years of age (less than high school, high school graduate or equivalent, some college or technical school, 4-y degree or higher) in addition to age as the timescale.
[b]Proportional hazards assumption violated for product use variable ($p < 0.05$).

of exposure to phthalates, musk, and other fragrances,[4] was associated with incident BC. Thousands of chemicals can be used as fragrances in cosmetics, and fragrance components do not have to be listed in product ingredients.[56] Women of different racial and ethnic backgrounds may choose different product types and brands,[3] and the chemical composition of products may vary depending on whether they are targeted to minoritized groups vs. White women,[34] which may contribute to differences in the BC associations for specific product types by race and ethnicity.

Latent classes representing greater hair product use, characterized based on higher frequency of use of more types of products, were suggestively associated with BC in Black and Latina women. Single-product models suggested that pomade use, which is strongly patterned by race, may be associated with higher risk. Hair pomades are leave-in maintenance products used to smooth, moisturize, and style hair and may be water-, oil- or wax-based.[48] In general, leave-in products have been found to have higher concentrations of some chemicals, including phthalates and parabens, than rinse-off products[1] and remain on the hair or scalp until the next shampoo, which may result in greater absorption.[37,57] Our questionnaire did not distinguish between rinse-off and leave-in conditioner and did not include use of other hair products, such as hair oils and lotions, which are used more frequently by Black and Latina women[37] and have been linked to reproductive and endocrine-sensitive outcomes.[58–60] Use of other hair products by pomade users may contribute to the associations we observed.

Previous studies of hair and skincare products that are popular among Black women found that most contained EDCs[34] and demonstrated either estrogenic or anti-estrogenic activity *in vitro*.[61,62] Petroleum jelly (petrolatum), frequently used by Black women in our cohort as a skin moisturizer and also an ingredient in some pomades,[48] exhibited estrogenic activity[61] and can be contaminated by polycyclic aromatic hydrocarbons,[56] endocrine-disrupting and carcinogenic compounds that are associated with BC risk.[5] The estrogenic or anti-estrogenic activity of each product was not predictable based on their ingredients, suggesting the importance of product-specific chemical mixtures.[61] Differences in the chemical constituents and hormonal activity within the same types of skincare products (e.g., cocoa butter cream was anti-estrogenic, whereas other lotions were estrogenic[61]) may explain why there were no clear trends overall for skincare/hygiene products with BC incidence and some differences by race and ethnicity. Among Black women, HRs suggested a possible modest increase in risk associated with the latent class characterized by frequent lotion and moisturizer use and for single-product models of these commonly used products (body lotions, body oils, and petroleum jelly).

Previous analyses in the Sister Study have observed higher BC risk associated with greater beauty product use in the 12 months before enrollment, assessed first using latent class-based groupings of adult product use[18] and more recently using quantile-based g-computation to estimate joint effects of use of multiple products.[20] Associations with adult use were observed in White but not Black women,[18,20] and adult use of lipstick, nail products, and perfume were not associated with BC in single-product models in the full cohort.[20] Latent classes of hair product use in the year before enrollment were not associated with BC incidence in Black or White women.[18] These inconsistencies with our findings for adolescent use suggest that use of beauty and hair products during puberty may influence BC risk independent of use later in life, but we did not conduct mediation analyses to quantify the direct effects of PCP use during puberty on BC incidence after accounting for the potential pathway through adult

Table 5. Associations between self-reported use of single skincare/hygiene products during the 10- to 13-years-of-age period and incident breast cancer by race and ethnicity in the Sister Study.

	Black or African American ($n = 4,049$)			Non-Black Hispanic/Latina ($n = 2,104$)			Non-Hispanic White ($n = 39,312$)		
Product	Use	*n* cases	Adjusted HR (95% CI)[a]	Use	*n* cases	Adjusted HR (95% CI)[a]	Use	*n* cases	Adjusted HR (95% CI)[a]
Body lotions or creams	Frequently	157	1.18 (0.80, 1.75)	Frequently	28	1.26 (0.78, 2.05)	Frequently	250	0.91 (0.79, 1.04)
	Sometimes	81	1.26 (0.84, 1.90)	Sometimes	41	1.00 (0.65, 1.53)	Sometimes	1,305	0.96 (0.89, 1.03)
	Did not use	34	1 (Ref)	Did not use	53	1 (Ref)	Did not use	1,415	1 (Ref)
Hand lotions or creams	Frequently	124	1.02 (0.71, 1.48)	Frequently	22	0.97 (0.58, 1.63)	Frequently	283	0.85 (0.74, 0.97)
	Sometimes	105	1.18 (0.81, 1.71)	Sometimes	50	1.03 (0.69, 1.54)	Sometimes	1,577	0.93 (0.86, 1.01)
	Did not use	38	1 (Ref)	Did not use	49	1 (Ref)	Did not use	1,100	1 (Ref)
Foot lotions or creams	Frequently	25	0.96 (0.63, 1.45)	Frequently or sometimes	21	1.20 (0.75, 1.92)	Frequently	12	0.66 (0.37, 1.15)
	Sometimes	35	0.83 (0.58, 1.19)				Sometimes	144	0.85 (0.72, 1.00)
	Did not use	213	1 (Ref)	Did not use	102	1 (Ref)	Did not use	2,919	1 (Ref)
Baby oil or mineral-based oils	Frequently[b]	55	1.23 (0.88, 1.72)	Frequently	7	1.16 (0.52, 2.60)	Frequently	172	0.97 (0.83, 1.13)
	Sometimes[b]	113	1.23 (0.94, 1.62)	Sometimes	36	0.85 (0.57, 1.27)	Sometimes	1,253	0.98 (0.90, 1.05)
	Did not use[b]	101	1 (Ref)	Did not use	79	1 (Ref)	Did not use	1,589	1 (Ref)
Petroleum jelly	Frequently	139	1.13 (0.80, 1.59)	Frequently or sometimes	24	0.92 (0.59, 1.43)	Frequently	48	0.93 (0.70, 1.24)
	Sometimes	94	0.97 (0.68, 1.40)				Sometimes	599	0.97 (0.89, 1.06)
	Did not use	42	1 (Ref)	Did not use	100	1 (Ref)	Did not use	2,352	1 (Ref)
Skin lighteners	Frequently or sometimes	17	1.20 (0.73, 1.96)	Frequently or sometimes	<5[c]	NE[c]	Frequently or sometimes	5	0.97 (0.40, 2.35)
	Did not use	261	1 (Ref)	Did not use	128	NE[c]	Did not use	3,129	1 (Ref)
Self-tanning products	Frequently or sometimes	<5[c]	NE[c]	Frequently or sometimes	6	1.01 (0.45, 2.28)	Frequently	9	0.94 (0.49, 1.81)
							Sometimes	147	0.93 (0.79, 1.10)
	Did not use	276	NE[c]	Did not use	121	1 (Ref)	Did not use	2,965	1 (Ref)
Bath or shower gel	Frequently	19	1.06 (0.66, 1.70)	Frequently or sometimes	8	0.66 (0.32, 1.38)	Frequently	44	1.14 (0.85, 1.54)
	Sometimes	26	0.99 (0.65, 1.50)				Sometimes	121	0.93 (0.77, 1.12)
	Did not use	231	1 (Ref)	Did not use	115	1 (Ref)	Did not use	2,919	1 (Ref)
Shaving cream or gel	Frequently or sometimes	20	0.89 (0.56, 1.42)	Frequently or sometimes	25	0.96 (0.61, 1.51)	Frequently	130	1.13 (0.95, 1.35)
							Sometimes	669	1.01 (0.93, 1.11)
	Did not use	253	1 (Ref)	Did not use	99	1 (Ref)	Did not use	2,205	1 (Ref)
Deodorant or antiperspirant	Frequently	224	1.45 (0.86, 2.44)	Frequently	60	0.89 (0.57, 1.39)	Frequently	1,336	1.02 (0.93, 1.12)
	Sometimes	31	0.91 (0.49, 1.68)	Sometimes	24	0.84 (0.49, 1.44)	Sometimes	861	0.95 (0.86, 1.04)
	Did not use	16	1 (Ref)	Did not use	31	1 (Ref)	Did not use	740	1 (Ref)
Face cream or moisturizer	Frequently	24	0.94 (0.62, 1.44)	Frequently	6	0.67 (0.29, 1.57)	Frequently[b]	107	0.95 (0.78, 1.15)
	Sometimes	40	0.92 (0.65, 1.29)	Sometimes	15	0.95 (0.55, 1.65)	Sometimes[b]	438	1.01 (0.91, 1.12)
	Did not use	210	1 (Ref)	Did not use	106	1 (Ref)	Did not use[b]	2,522	1 (Ref)
Cleansing cream	Frequently	8	0.59 (0.29, 1.20)	Frequently	5	0.84 (0.34, 2.10)	Frequently	117	0.96 (0.79, 1.15)
	Sometimes	23	0.61 (0.40, 0.95)	Sometimes	17	0.95 (0.57, 1.59)	Sometimes	456	1.04 (0.94, 1.15)
	Did not use	245	1 (Ref)	Did not use	105	1 (Ref)	Did not use	2,498	1 (Ref)
Face masks	Frequently or sometimes	13	1.25 (0.71, 2.21)	Frequently or sometimes	12	1.15 (0.62, 2.15)	Frequently or sometimes	190	1.13 (0.97, 1.31)
	Did not use	265	1 (Ref)	Did not use	115	1 (Ref)	Did not use	2,927	1 (Ref)
Blemish or acne products	Frequently	20	1.15 (0.73, 1.81)	Frequently	8	0.72 (0.34, 1.51)	Frequently	473	1.16 (1.04, 1.29)
	Sometimes	60	1.03 (0.77, 1.38)	Sometimes	33	0.97 (0.64, 1.48)	Sometimes	1,094	1.07 (0.98, 1.16)
	Did not use	196	1 (Ref)	Did not use	85	1 (Ref)	Did not use	1,500	1 (Ref)
Mouthwash or rinse	Frequently	71	1.13 (0.83, 1.55)	Frequently	7	0.65 (0.30, 1.40)	Frequently	129	1.08 (0.90, 1.29)
	Sometimes	100	1.00 (0.76, 1.33)	Sometimes	32	0.92 (0.61, 1.40)	Sometimes	762	0.95 (0.88, 1.04)
	Did not use	99	1 (Ref)	Did not use	77	1 (Ref)	Did not use	2,065	1 (Ref)
Talcum powder under arms	Frequently	24	1.14 (0.74, 1.75)	Frequently	6	1.03 (0.44, 2.42)	Frequently	89	0.96 (0.78, 1.19)
	Sometimes	93	1.05 (0.81, 1.36)	Sometimes	27	0.89 (0.58, 1.39)	Sometimes	609	0.93 (0.85, 1.02)
	Did not use	149	1 (Ref)	Did not use	89	1 (Ref)	Did not use	2,239	1 (Ref)

Table 5. (*Continued.*)

Product	Black or African American ($n = 4{,}049$)			Non-Black Hispanic/Latina ($n = 2{,}104$)			Non-Hispanic White ($n = 39{,}312$)		
	Use	*n* cases	Adjusted HR (95% CI)[a]	Use	*n* cases	Adjusted HR (95% CI)[a]	Use	*n* cases	Adjusted HR (95% CI)[a]
Talcum powder on genital area	Frequently	25	1.13 (0.74, 1.73)	Frequently or sometimes	16	0.79 (0.47, 1.32)	Frequently	73	1.01 (0.80, 1.27)
	Sometimes	72	0.91 (0.69, 1.19)				Sometimes	429	0.92 (0.83, 1.02)
	Did not use	177	1 (Ref)	Did not use	111	1 (Ref)	Did not use	2,511	1 (Ref)
Talcum powder on other areas	Frequently	36	0.96 (0.66, 1.40)	Frequently	7	0.80 (0.37, 1.73)	Frequently	121	0.94 (0.78, 1.12)
	Sometimes	127	1.00 (0.77, 1.30)	Sometimes	41	0.85 (0.58, 1.26)	Sometimes	1,074	0.92 (0.85, 0.99)
	Did not use	105	1 (Ref)	Did not use	69	1 (Ref)	Did not use	1,717	1 (Ref)

Note: Participants with missing data on the product of interest are excluded from single-product model. CI, confidence interval; HR, hazard ratio; NE, not estimated; Ref, reference.
[a]Adjusted for birth cohort in ~ 10-y intervals, family income level growing up (well off, middle income, low income, poor), and maximum household education level at 13 years of age (less than high school, high school graduate or equivalent, some college or technical school, 4-y degree or higher) in addition to age as the timescale.
[b]Proportional hazards assumption violated for product use variable ($p < 0.05$).
[c]We did not estimate associations for products with <5 exposed cases. To protect participant confidentiality, we do not report exact case numbers if <5.

use. Changes in chemical composition of products over time or differences in products used in adolescence vs. adulthood could contribute to differences in risk by age at use. Patterns of adult product use in Black women also may not have been well characterized in the prior LCA, which was not stratified by race.

Previous studies of adult use of skincare/hygiene products and BC risk have yielded inconsistent findings, including within the Sister Study.[18,20] Use of hand and facial cream and skin lotion was not associated with BC incidence in a Norwegian cohort.[19] Skin lighteners were not associated with BC risk in Ghanaian women,[27] which is in line with our null results for adolescent use in Black women. Deodorant/antiperspirant use in adulthood has not been found to be associated with BC risk,[21] consistent with our findings for adolescent use. We observed a positive association of use of blemish/acne products with BC in White women. This is consistent with a previous Sister Study finding that severe acne in adolescence, a potential marker of higher endogenous hormone concentrations during puberty, was associated with increased BC risk.[63]

PCPs contain complex mixtures of biologically active chemicals with potential endocrine-disrupting, genotoxic, and carcinogenic effects that may influence BC risk.[5,56] Animal studies support that exposure to environmental chemicals during puberty, a vulnerable window for carcinogenesis owing to the rapid proliferation of breast cells that are not fully differentiated,[5,6,22] can disrupt mammary gland development and influence cancer risk.[5,7,10,64] Few studies have examined environmental exposures specifically during puberty and BC risk in women.[5,22] A recent analysis in the Life Span Study of atomic bomb survivors found that BC risk associated with ionizing radiation exposure increased as the age at exposure approached menarche, was at its peak in women exposed around the time of menarche, and then declined.[65] In the Child Health and Development Studies, women exposed to DDT after infancy through puberty (3–13 years of age) were at increased risk of BC at <50 and at 50–54 years of age.[66] Our findings in the Sister Study linking use of some PCPs during the 10- to 13-years-of-age period with increased BC risk, in addition to prior work on straightener/relaxer use,[26] add to this evidence base supporting that environmental exposures around the time of puberty influence BC risk.

We asked about product use during the 10- to 13-years-of-age period as a proxy for the pubertal period, but this age range does not directly correspond to the timing of puberty in individual participants. More than 80% of participants reported experiencing thelarche, usually the first physical sign of pubertal onset,[67] by 14 years of age. We hypothesized that women with early thelarche, who on average experience a longer duration of development than women with later thelarche,[68] would be more vulnerable to the effects of EDCs during this critical window. Contrary to that hypothesis, among White women, point estimates for classes characterized by greater product use were positive (although imprecise) only among girls with late thelarche. A possible explanation is that the breast may be more vulnerable to the influence of exogenous estrogens found in products when endogenous hormone levels are low, as in prepubertal girls.[61] Because product use often increases during puberty, it is also possible that women with late thelarche who reported more frequent PCP use during the 10- to 13-years-of-age period misreported their age at thelarche as occurring after 13 years of age when it really happened earlier. If this is the case, the elevated HRs for more frequent product use in this group may reflect the increased BC risk associated with earlier age at thelarche that we previously observed in the cohort.[42]

PCP use in childhood could influence BC risk by affecting the timing of puberty.[37] Childhood use of some hair products has

been associated with premature breast development[69] and earlier menarche[58] in Black girls, but findings from epidemiological studies of PCP-related EDC biomarker concentrations and pubertal timing are inconsistent overall.[70] We did not have data on PCP use prior to 10 years of age so we could not examine whether childhood PCP use influences BC incidence through altered timing of thelarche or menarche.

The use of the large and diverse Sister Study cohort is a strength of this analysis, allowing us to account for racial and ethnic differences in product use. Even so, the smaller sample sizes for Black and Latina women affected the precision of the effect estimates and limited our ability to stratify or detect statistical heterogeneity. For example, we lacked sufficient cases of premenopausal and ER-negative cancers to evaluate whether PCP use during puberty contributes to disparate risks of these more aggressive cancers in Black and Latina women.[71–73] We also could not stratify by timing of thelarche in Black or Latina women, who are at increased risk of early thelarche compared with White women.[74]

We classified women into broad categories based on self-reported race and ethnicity that are only a crude proxy for lived experiences of structural racism and discrimination. We did not examine women who self-identified as Black and at least one other race or as Black and Latina separately from women who self-identified as Black only owing to small numbers ($n = 352$). Because the number of non-Black Latina participants was relatively small ($n = 2{,}104$), we did not disaggregate by subpopulation based on origin or culture or consider race within this group. Prior studies observed distinct patterns of PCP use among Asian women compared with other races and ethnicities,[29,31] but we had too few women who self-identified as Asian, Pacific Islanders, American Indians, or Alaska natives to examine these groups. We did not account for intersectionality of other identities (e.g., gender identity, sexual orientation, SES) that influence lived experiences and, potentially, PCP use.[32,33,75] Our results could also be subject to residual confounding by other sources of chemical exposures during childhood, such as food packaging, use of other consumer products, and ambient environmental exposures. The Sister Study is a relatively high-SES, volunteer cohort and all participants have a family history of BC, which may limit the generalizability of our findings to the broader population. However, estimated associations are internally valid and an advantage of the family-based design is the enhanced ability to detect effects of environmental exposures that interact with genetic factors.[76,77] Sisters also likely share lifestyles and early life exposures, so sisters of women with BC may be more likely to have early life exposures related to increased BC risk,[76] improving our ability to detect these associations.

A strength of this analysis is the use of latent class models to identify groups of women with similar product use patterns, which reduced the dimensionality of the correlated, single-product data and characterized patterns of joint product use that occur in real-life settings.[78] We did not account for uncertainty in probability-based latent class assignment in our BC models, which can produce a bias toward the null.[46,79] A limitation of the latent class approach, which is agnostic to the outcome of interest, is that it may obscure associations of specific products with BC risk. Products differ in terms of the types of chemicals or concentrations of chemicals included[4] and may differentially influence susceptibility to breast carcinogenesis. Frequency of exposure could also vary across products included in a particular latent class. For example, the latent class analyses of beauty products grouped "frequent" and "sometimes" users of makeup products into the same identified class. Thus, our single-product analyses are an important addition and identified specific products that may warrant additional research, despite the possibility of false-positive findings due to multiple testing. Single-product analyses also provide context relevant to the interpretation of the latent class findings by singling out products that may be driving class-level associations. We did not adjust for multiple comparisons because the trade-off of decreasing the likelihood of false-positive findings is an increase in the likelihood of false-negative findings.[80,81] However, results from single-product models should be interpreted with caution, and subsequent studies are needed to confirm our findings.

Participants recalled their product use during the 10- to 13-years-of-age period at baseline, which was anywhere from 25 to 64 y later, depending on age at enrollment. The validity of this recalled data is not known, an important limitation of this work. We recently reported that Sister Study participants can generally recall lifetime use of feminine hygiene products with good consistency across two time points,[82] although the reliability of use during the 10- to 13-years-of-age period specifically could not be estimated owing to differences in the ages when use was assessed on the enrollment and follow-up questionnaire. We asked about adolescent product use using broad categories, which may have minimized misclassification, but the response options of "sometimes" and "frequently" were subject to participants' interpretation. Owing to the prospective study design, we expect exposure misclassification to be non-differential by BC status, resulting in a potential underestimation of associations of frequent use with BC risk. We did not have information on the specific products/brands used and could not evaluate the constituent chemicals that women were exposed to. The chemical formulations of products on the market when the participants were 10–13 years of age may have changed across the birth cohorts included in our study and likely differ from products available today. Some changes to product formulations have been prompted by consumer concerns regarding chemical exposures,[83,84] so our results may not be generalizable to BC risk associated with PCP use among current adolescents.

In conclusion, our findings provide some support for the hypothesis that frequent use of some PCPs during puberty is associated with increased BC risk. Additional research is needed to corroborate our findings, examine adolescent use of products currently on the market and the chemical constituents within these products that contribute to increased risk, and consider how differences in early life PCP use by race and ethnicity contribute to BC disparities. PCP use is a potentially modifiable source of exposure to EDCs that is amenable to multiple levels of intervention, including changes to individual product use,[85] product formulations,[84] and policy or product regulations.[86,87] More research is needed to further investigate whether reducing PCP use around puberty could provide an opportunity for BC risk reduction starting early in life.

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Data sharing: Requests for data, including the data used in this manuscript, are welcome. De-identified data is made available upon request as described on the study website (https://sisterstudy.niehs.nih.gov/English/data-requests.htm). The data sharing policy was developed to protect the privacy of study participants and is consistent with study informed consent documents as approved by the NIEHS institutional review board.

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